Public Transportation, IoT, Trust and Urban Habits

Andrea Melis[1(✉)], Marco Prandini[2], Laura Sartori[3], and Franco Callegati[1(✉)]

[1] Department of Electrical, Electronic and Information Engineering, University of Bologna, Bologna, Italy
{a.melis,franco.callegati}@unibo.it
[2] Department of Computer Science and Engineering, University of Bologna, Bologna, Italy
marco.prandini@unibo.it
[3] Department of Political and Social Sciences, University of Bologna, Bologna, Italy
l.sartori@unibo.it

Abstract. The technological compound known as Internet of Things is enabling massive transformations in many fields. In this paper, we deal with one emerging scenario, Mobility as a Service, where the interplay between technical, regulatory and social aspects is intense. We advocate the need for interdisciplinary research, taking into account the different facets of a system which, in summary, aims at improving the quality of urban life by collecting personal data, tracking citizens' movements, correlating them with many other sources of information, and making the results widely available.

Keywords: Internet of Things · Mobility as a Service · Trust · Urban habits · Data collection · Governance

1 Introduction

Historically, infrastructures, administrations and citizens have been intertwined (to a certain degree) in a mutual, but non-linear, process of societal development. Transportation is a hot topic for big cities and regional districts in both developed and developing countries. Public transportation emerges as an even more crucial theme for future sustainability, especially in high density territories. If it is true that since the Fifties the time budget (in hours) allocated to urban transportation is stable while the number of kilometers steadily increased (the so-called Zahavi's conjecture), it means that at least part of the potential positive effects of transport innovations (alternative means of transport, integrated systems of mobility) has not been fully deployed and, thus, was lost. Now, a paradigm shift is happening from seeing mobility as a problem of infrastructure to designing mobility as a service (MaaS) to the community. The new paradigm offers a smart and sustainable optimization of urban mobility in complex and multidimensional metropolitan areas, but it requires pervasive, real-time data

F. Bagnoli et al. (Eds.): INSCI 2016, LNCS 9934, pp. 318–325, 2016.
DOI: 10.1007/978-3-319-45982-0_27

collection and analysis, making it a prime application of the Internet of Things (IoT) model. Thus, it is important to start addressing both technical and social implications of IoT in order for potential benefits to be effectively realized.

In this paper we address technical and social implications of IoT in a specific setting: public transportation in urban contexts. By acknowledging the crucial role of the transport infrastructure for 'smart' territories and cities of tomorrow, we propose to start over and think about public transportation by changing the core premise: mobility cannot be anymore thought of just as an area of basic and standard public regulation, but as a Service. As such, mobility becomes an integrated framework for urban policy-making. From a technological PoV IoT allows for this innovative approach about Mobility as a Service (MaaS) (Sects. 2 and 3) connecting to stringent urban and social issues (Sect. 4). From a sociological perspective, we address three main points: the city as a whole, a pro-active regulatory approach and trust towards technology. Investigating mobility by a multidisciplinary eye has already served to pinpoint relevant areas for future research.

2 Public Transport in the IoT Age

In recent decades, public transport services steadily profited from the introduction of new technologies. The means of transport became faster, less polluting, more comfortable and accessible. The interaction of passengers with transport services became easier, as ticketing and payment systems went from paper to electronic and on-line planning and real-time information systems became available. Through more efficient exchange of information, transport operators began to see the interoperability between competitors as an added value (for example: coordination at transfer points can lead to better service, attracting more customers than it would happen by aggressively competing for the same route). The advent of IoT, however, potentially represents a real revolution for public transportation. Independent processes that required specific investments to deal with business needs (e.g., fleet management, fulfilment of quality of service obligations, route optimization, etc.) can be all seen as by products of a single platform, where thousand of autonomous objects can constantly acquire data captured from their surroundings, analyse them for local decision making and forward them to third parties [13]. These data are used to improve services' efficiency, and to make them smarter and more customized. In this picture, the citizens are not simply end users any more, but become components of the service itself and contributors to its development. Out of the many examples that confirm this claim, a few are provided hereinafter.

2.1 Case Studies

In various contexts, pilot projects as well as large-scale deployments have proven the value of the technologies that now compose the foundations for IoT.

Transport for London (TFL) has already implemented a huge network collecting data through devices, such as ticketing systems, sensors attached to vehicles, and traffic signals, but also by means of surveys, focus groups, and social media [6]. These data have manifold uses: for example, a single "journey mapping" application can aggregate anonymized data to allow the study of overall flows, or to produce real-time maps showing passengers the network status, as well as more individual analyses through personalized travel habits. Data analysis also helps TFL respond in an agile way when unexpected events occurs and travel data is also used to identify customers who regularly use specific routes and send tailored travel updates to them.

Similarly, the Kontron Intel architecture was used to create a map representation of traffic, depicting realistic vehicular mobility traces of downtown Portland, Oregon [5]. With this map, the authors were able to organize traffic by directing vehicles through the most suitable paths according to traffic congestion. This work focused on cars, but the principle could be adapted to all public transport, taking into account route constraints.

Other examples of the same kind can be found in adapted Markov chains, fed by real-time traffic information, to predict congestion trends on freeways [14], while in another case study [9] smart-phones embedded sensors are used to create a network of vehicles to track the availability of parking spaces, suggesting where to park.

Gubbi et al. [2] defined otherwise a cloud-centric version of an IoT network system contextualized for the design of traffic management in medium and big cities. They proposed a framework enabled by a mix of public and private clouds in order to provide the capacity to utilize the IoT. Following these results, Leng and Zhao [4] provided a practical implementation of this kind of IoT network for traffic management, realized with a cloud-centric monitoring system of vehicles. Viviani's work [16] describes a technical solution adopted in the Padova Smart City project, a proof of concept deployment created in collaboration with the city municipality, that pushes the same concepts further towards the idea of MaaS.

3 MaaS and the Future for Mobility

Mobility as a Service [10] is an innovative approach to the integration of public and private transport, made viable by the integration in a coordinated infrastructure of the technologies illustrated in the previous section. Born in the city of Helsinki, this paradigm is starting to spread throughout Europe and beyond, aiming to establish standards for the interoperability between different (even in terms of country) operators, and to encourage the creation of alternative solutions to the standard "mass transit/private car" duality, as both new technologies and social trends emerge [7].

Very briefly, the principle of MaaS is that as long as every detail of the demand and supply for transportation services is known in real-time, there is no need for passengers to commit on specific means. Instead, they will enjoy a broad spectrum of alternatives from which to choose, taking into account the needs of the moment. For example, one could specify a very strict set of constraints in terms of comfort and timing, likely to result in a choice of premium means, while another could simply express the need for reaching a destination at the best price, getting a virtual ticket, and receiving real-time instructions about which means to use to complete the trip. Many business models are possible. In the simplest form, a MaaS operator could simply be a smart broker for planning and paying trips on existing networks. A more innovative way would be selling mobility packages allowing travelers to use pre-configured amounts of usage of different means. From the transport operators viewpoint, a MaaS platform could be a great opportunity to leverage integration and to exploit unused capacity. For example, a taxi company exposing vehicle availability and position in real-time could offer lower prices during off-peak times, thus appearing as a good alternative to mass transit; data-mining could allow operators to foresee correlations between various conditions (events, weather, accidents) and transportation needs, to allocate materials in the best possible way. Ideally, the ICT infrastructure enables these models by tracking timing, position, and availability of trains, buses, subways, shared bikes, shared cars, taxis, Uber cars, Lyft cars, etc. in an overall effort of opening data and standardizing the interfaces to access them [15]. In short, in a mobility context, both the users and the operators can benefit from the smart definition of trips, provided enough availability of data and efficiency of processing is available. This is exactly the kind of challenge IoT architectures are up to [11].

Thus, the role of public administration can undergo a significant change. Some administrations could choose to play the role of a central MaaS operator, exerting a stronger control on the local mobility agenda. Others could leave the field to private companies, hoping to benefit from market-driven optimization of citizens' patterns of mobility. They could also accurately monitor citizens, using collected data to plan investments and direct incentives towards specific goals. The first scenario allows for a more respectful and regulated approach to citizens' privacy while the second leaves room for malevolent or misleading collection and use of data. One example of the latter is Google legal advisor David Drummond's defensive reply to the question about future uses of data collected by their driverless car [8]. According to authors, it is too early to regulate over the driverless-car about data collection and uses, because it is not yet foreseeable what is worth (implicitly 'for the company'). In any case, governments will need to face the challenges MaaS provide, and to think about needed regulatory changes to make it viable for innovative cities. The adoption of MaaS will sustain a transition from a public transport system traditionally coordinated by the government to a multi-faceted system where exert coordination through the help of other actors. For example, determining who is in charge of setting the standards will affect business and consumers in parallel with data protection policies.

It is worth noticing that, in many places, this change could introduce significant trust issues. The organization of transport infrastructures by public bodies guarantees (at least in principle) that travelers' interests are safeguarded. In a fuzzier scenario, it could be very difficult to verify how sensitive data are processed and by whom, as detailed in Sect. 4.3.

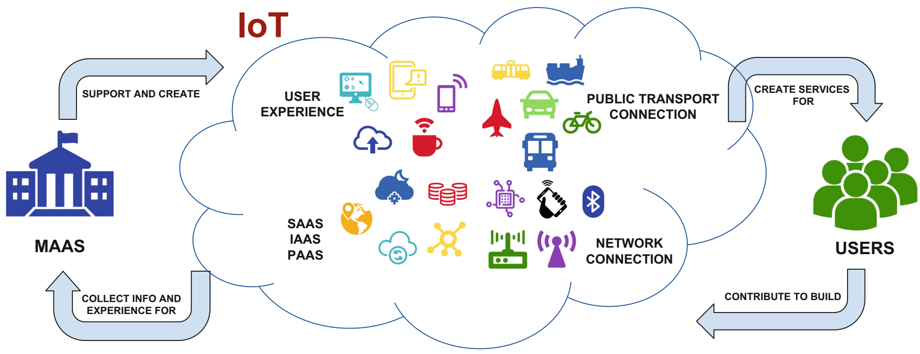

Fig. 1. Maas, IoT and user work-flow

Figure 1 illustrates a development scenario of MaaS. The central cloud is the concept of IoT architecture understood as a heterogeneous set of networks, technologies and experiences. The user enjoys the huge power of the IoT infrastructure and its vast datasets, yet at the same time he enriches the IoT by providing valuable information from mobile devices' sensors and from his own user experience, as well as contributing additional computational power ("fog computing").

The MaaS' role is twofold too, in that it uses infrastructural functions and user data to create many layers of value-added applications, which enlarge the set of available IoT services.

4 Social Implications of IoT and MaaS

Technology always takes a user to 'tango', even though seldom it is a learnt lesson. Social implications of IoT and its siblings, such as MaaS-enabling infrastructures, are still to be empirically investigated, but three issues are already worth mentioning.

4.1 Not only Mobility, It Is About the Whole City!

Rethinking mobility means thinking about the whole city (or territory) with all the social and economic complexity it brings along. Citizens live and experience, innovate or destroy the city, moving within it. Daily routines and social trends in public or private domains offer grounds to better conceptualize mobility. Moreover, in the last decades, users have been progressively accustomed to have more autonomy in the uses they make out of technology (e.g., from the more traditional mass media to the malleable family of ICTs). IoT-powered platforms kindly welcome and incorporate users' feedback in a potential virtuous circle. Since urban mobility is not the only aspect of urban life that users engage in, it is likely that feedback about 'mobility' already incorporate and reflect other daily routines (about work, leisure and family habits). Thus, MaaS could offer optimized solutions to mobility that are 'embedded' in social contexts in contrast with more top-down and thought-in-silos solutions. Thinking about the whole city and its dynamics (and not only about transportation) also offers a potential for nudging. A deep knowledge about urban life is essential to policies that sustain and encourage more sustainable behaviours (e.g., nudging and giving suggestions to include walking in daily routines, to combine "transportation", healthy behaviour, and street liveliness). Mobility is a fundamental piece of the city life that needs to be thought as a part of a more general urban agenda.

4.2 A New Pro-active Approach to Policy-Making

Successful policies show a deep understanding of the context they intend to regulate. Lately, bottom-up contributions to policy-making have been possible and emphasized through the power of ICTs, social media and so forth. Yet, a lot can still be done in a more traditional, but effective, way. When it comes to urban mobility combined with technological innovations, policymakers could make a first move engaging with relevant actors to collect all possible insights about existing needs (as explained in previous paragraphs). This pro-active approach reaches the goal of a deeper understanding of the context while listing also all possible existing constraints. For sure, there are regulatory constraints that, if not adapted and molded to the new context, could limit possible innovations. There is a need for a change in the regulatory framework that is thought to govern hundreds of transactions or services, not millions of connected things (and their data). What level of de-regulation and what kind of new rules policy-makers will come up with is a truly interesting area of research.

4.3 Trust

Why and to what extent should one trust IoT for mobility? Security directly relates to trust as users have to be confident that IoT applications are secure from cyberattacks or external misuses, like any other networked environment. From a technical point of view, IoT security should be thought of a device vulnerability in an evolutionary process supported by threat-and-solutions to emerging security issues [3]. Debating over security issues is not new in IT, but the scale to 'unique' challenges to IoT make it even more central [12]. From a sociological point of view, privacy and awareness arise as crucial aspects of security when the classic model of 'terms and conditions' acceptance does not apply to IoT. Users do not have direct knowledge and control over IoT devices in order to express privacy preferences in their daily uses of IoT applications or in the management of the data collection that either 'tap into' or 'feed into' the increasing big data analytics. Thus, it is quite difficult to seize and adapt IoT apps to the social norms underlying what is deemed to be private, public or shareable. If the Internet changed the boundaries of the right to privacy, IoT threatens to go even further. In this respect, future technical developments should look closely to privacy-by-design principles and privacy preferences in order to set the basis for higher fairness in data collection and use.

When it comes to mobility, security is linked to trust also because individuals need to be safe when using transportation means which are totally new (e.g., self-driving cars [17]) or which could be perceived as threatening (e.g., shared cars with unknown drivers). As an example, gender or age perspectives could help in designing mobility as a service considering different needs in terms of easiness and safeness in public spaces. By the same token, IoT apps could be effectively used for law enforcement and public safety (monitoring urban areas, recovering stolen cars, etc.). Yet, they could be also maliciously put at work to monitor single individuals that are no criminals as in the recent case of Banksy (where researchers used crime prevention analytics and mobility maps to match and uncover who could possibly be identified as the famous street artist [1]).

5 Conclusions

As soon as public transportation is acknowledged as a service it could become a smart tool for urban governance. Not only can urban mobility be updated through a mix of new and existing solutions, but it can be shaped along with emerging societal trends in public and private domains that affect urban life. It is important to accumulate and store urban knowledge not confined to urban mobility in order to proactively design smart policies. Moreover, IoT and MaaS could offer new chances for designing ways by which to build and consolidate users' trust and confidence towards technology.

Therefore, technological solutions could really empower and sustain innovative answers to mobility issues. Yet, it could be so, only if we share a perspective where social, political and urban needs meet technological opportunities.

References

1. Chandler, A.: Banksy unmasked? http://www.theatlantic.com/technology/archive/2016/03/banksy-unmasked/472152/
2. Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M.: Internet of things (IoT): a vision, architectural elements, and future directions. Future Gener. Comput. Syst. **29**(7), 1645–1660 (2013). http://www.sciencedirect.com/science/article/pii/S0167739X13000241, includingSpecial sections: Cyber-enabled Distributed Computing for Ubiquitous Cloud and Network Services; Cloud Computing and Scientific Applications Big Data, Scalable Analytics, and Beyond
3. Rose, K., Eldridge, S., Chapin, L.: The Internet of Things (IoT): an overview. Techical report, The Internet Society (ISOC), October 2015
4. Leng, Y., Zhao, L.: Novel design of intelligent internet-of-vehicles management system based on cloud-computing and internet-of-things. In: 2011 International Conference on Electronic and Mechanical Engineering and Information Technology (EMEIT), vol. 6, pp. 3190–3193, August 2011
5. Marfia, G., Pau, G., De Sena, E., Giordano, E., Gerla, M.: Evaluating vehicle network strategies for downtown portland: opportunistic infrastructure and the importance of realistic mobility models. In: Proceedings of the 1st International MobiSys Workshop on Mobile Opportunistic Networking, MobiOpp 2007, pp. 47–51. ACM, New York (2007). http://doi.acm.org/10.1145/1247694.1247704

6. Marr, B.: How big data and the internet of things improve public transport in london (2015). https://www.linkedin.com/pulse/how-big-data-internet-things-improve-public-transport-bernard-marr
7. Finger, M., Bert, N., Kupfer, D.: Mobility-as-a-Service: from the Helsinki experiment to a European model? Technical report, Observer European Transport Regulation (2015)
8. Phippen, J.W.: Who drives a driverless car? http://www.theatlantic.com/national/archive/2016/02/google-driverless-car/462153/
9. Salpietro, R., Bedogni, L., Felice, M.D., Bononi, L.: Park here! a smart parking system based on smartphones' embedded sensors and short range communication technologies. In: 2015 IEEE 2nd World Forum on Internet of Things (WF-IoT), pp. 18–23, December 2015
10. Pippuri, S., Hietanen, S., Pyyhtia, K.: Maas finland. http://maas.fi/
11. Hietanen, S.: CEO, ITS Finland. Mobility as a service the new transport model? Technical report, MaaS Finland (2014)
12. Sicari, S., Rizzardi, A., Grieco, L., Coen-Porisini, A.: Security, privacy and trust in internet of things: the road ahead. Comput. Netw. **76**, 146–164 (2015). http://www.sciencedirect.com/science/article/pii/S1389128614003971
13. Yate Team: Connecting public transport to the internet of things (2015). https://blog.yate.ro/2015/08/27/connecting-public-transport-to-the-internet-of-things/
14. Tian, D., Liu, C., Wang, Y., Zhang, G., Xia, H.: A freeway travel time predicting method based on iov. In: 2015 IEEE 2nd World Forum on Internet of Things (WF-IoT), pp. 1–5, December 2015
15. Viviani, M.: Mobility as a service (2015). http://www.webnews.it/2015/08/07/mobility-as-a-service/
16. Zanella, A., Bui, N., Castellani, A., Vangelista, L., Zorzi, M.: Internet of things for smart cities. IEEE Internet of Things J. **1**(1), 22–32 (2014)
17. Zetter, K.: Researchers hacked a models, but teslas already released a patch. http://www.wired.com/2015/08/researchers-hacked-model-s-teslas-already